US009427740B2

(12) **United States Patent**
Matthews

(10) **Patent No.: US 9,427,740 B2**
(45) **Date of Patent: Aug. 30, 2016**

(54) **VERTICAL TOP-FED GRAIN MILL**

(71) Applicant: **Satake USA, Inc.**, Stafford, TX (US)

(72) Inventor: **Peter Mathieson Matthews**, Katy, TX (US)

(73) Assignee: **Satake USA, Inc.**, Stafford, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 154 days.

(21) Appl. No.: **14/159,701**

(22) Filed: **Jan. 21, 2014**

(65) **Prior Publication Data**

US 2015/0202628 A1 Jul. 23, 2015

(51) **Int. Cl.**
B02C 9/00 (2006.01)
B02B 3/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B02B 3/04*** (2013.01); ***B02C 9/00*** (2013.01)

(58) **Field of Classification Search**
CPC B02C 2/10; B02C 4/02; B02C 7/08; B02C 9/00; B02C 9/02; B02C 3/04
USPC 241/74, 249, 257.1, 260
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,010,989	A *	8/1935	Hatton	241/43
3,477,855	A	11/1969	Freeman	
3,897,017	A	7/1975	Rogers et al.	
4,057,194	A	11/1977	Orton	
4,109,873	A	8/1978	Lichfield	
4,290,560	A	9/1981	Tabah	
4,323,006	A	4/1982	Satake	
4,426,921	A	1/1984	Meinardus	
4,426,922	A	1/1984	Yamamoto	
4,663,030	A *	5/1987	Chupka et al.	209/306
4,843,957	A	7/1989	Satake	
4,896,592	A	1/1990	Satake	
5,025,993	A	6/1991	Satake	
5,211,343	A	5/1993	Wellman	
5,271,570	A	12/1993	Satake et al.	
5,390,589	A	2/1995	Satake et al.	
5,394,792	A	3/1995	Satake	

(Continued)

FOREIGN PATENT DOCUMENTS

CN	2243333	12/1996
JP	0478452 A	3/1992

(Continued)

OTHER PUBLICATIONS

Shane Thomas, International Search Report—PCT/US15/11509, Apr. 13, 2015, 2 pages, U.S. Patent and Trademark Office as International Searching Authority, Alexandria, Virginia USA.

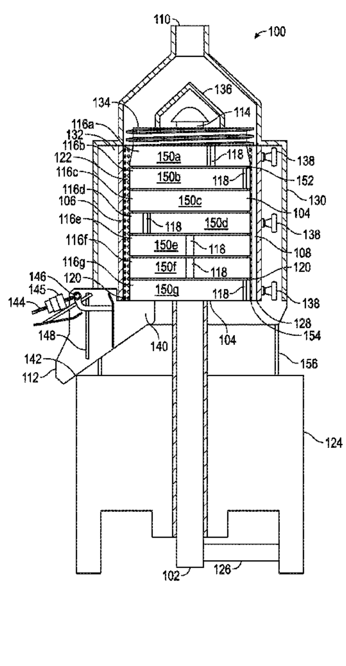
(Continued)

Primary Examiner — Mark Rosenbaum
(74) *Attorney, Agent, or Firm* — Crain, Caton & James, P.C.; James E. Hudson, III

(57) **ABSTRACT**

A top-fed vertical grain mill which causes intermittent compression of grains while reducing potential overmilling. The top-fed vertical grain mill includes a resistor bar, a plurality of rolls having a smooth, metal vertical outer periphery on which a vertically-aligned stirring bar is positioned, and a bran removal cylinder having a plurality of perforations therethrough, which may be throughout or which may be below the bottom surface of the top-most of the plurality of rolls.

18 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,511,731	A	4/1996	Schmidt	
5,752,664	A *	5/1998	Satake et al.	241/74
5,773,066	A	6/1998	Satake et al.	
5,846,591	A	12/1998	Satake et al.	
6,199,777	B1	3/2001	Satake et al.	
6,936,294	B2	8/2005	Matthews	
7,553,507	B2	6/2009	Matthews	
2005/0220952	A1	10/2005	Matthews	
2005/0226978	A1	10/2005	Matthews	
2005/0226979	A1	10/2005	Matthews	
2008/0226784	A1	9/2008	Matthews	
2011/0284670	A1	11/2011	Jenkins et al.	
2012/0067990	A1	3/2012	Seto	
2013/0119170	A1	5/2013	Pape	

FOREIGN PATENT DOCUMENTS

JP	04197455	A	7/1992
JP	0881063	A	3/1996
JP	10180126	A	7/1998

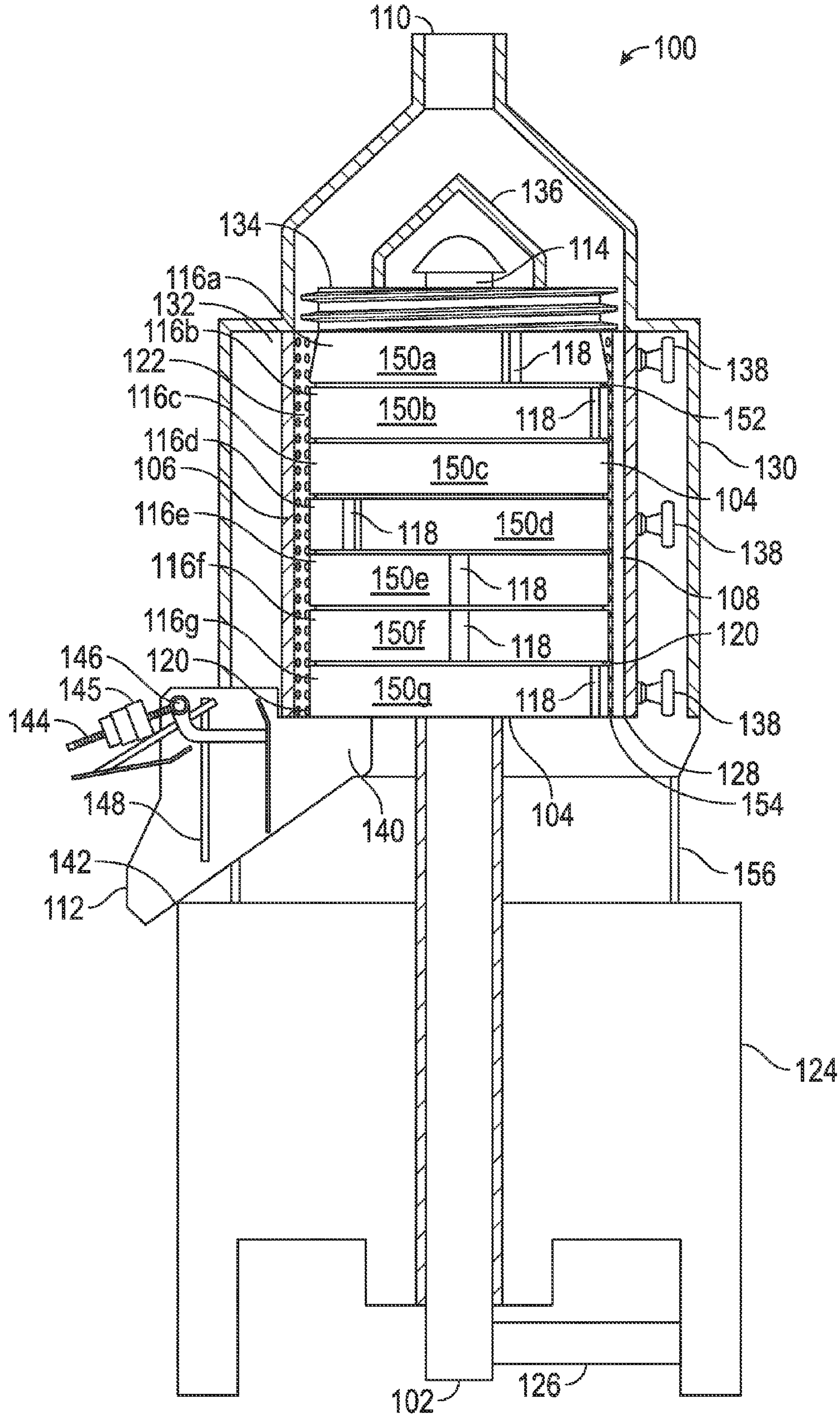
OTHER PUBLICATIONS

Shane Thomas, Written Opinion of the International Searching Authority—PCT/US15/11509, Apr. 13, 2015, 8 pages, U.S. Patent and Trademark Office as International Search Authority, Alexandria, Virginia USA.

Mark Rosenbaum, Written Opinion of the International Preliminary Examining Authority—PCT/US15/11509, Mar. 16, 2016, 3 pages, USPTO as Examining Authority, Alexandria, Virginia, USA.

Mark Rosenbaum, International Preliminary Report on Patentability-PCT/US15/11509, Jun. 22, 2016, 3 pages, USPTO as Examining Authority, Alexandria, Virginia, USA.

* cited by examiner



110
100
136
134
114
116a
132
116b
150a
118
138
122
150b
118
152
116c
150c
130
116d
104
106
118
150d
138
116e
150e
118
108
116f
150f
118
120
116g
150g
118
138
146
120
145
144
128
148
140
104
154
142
156
112
124
102
126

FIG. 1

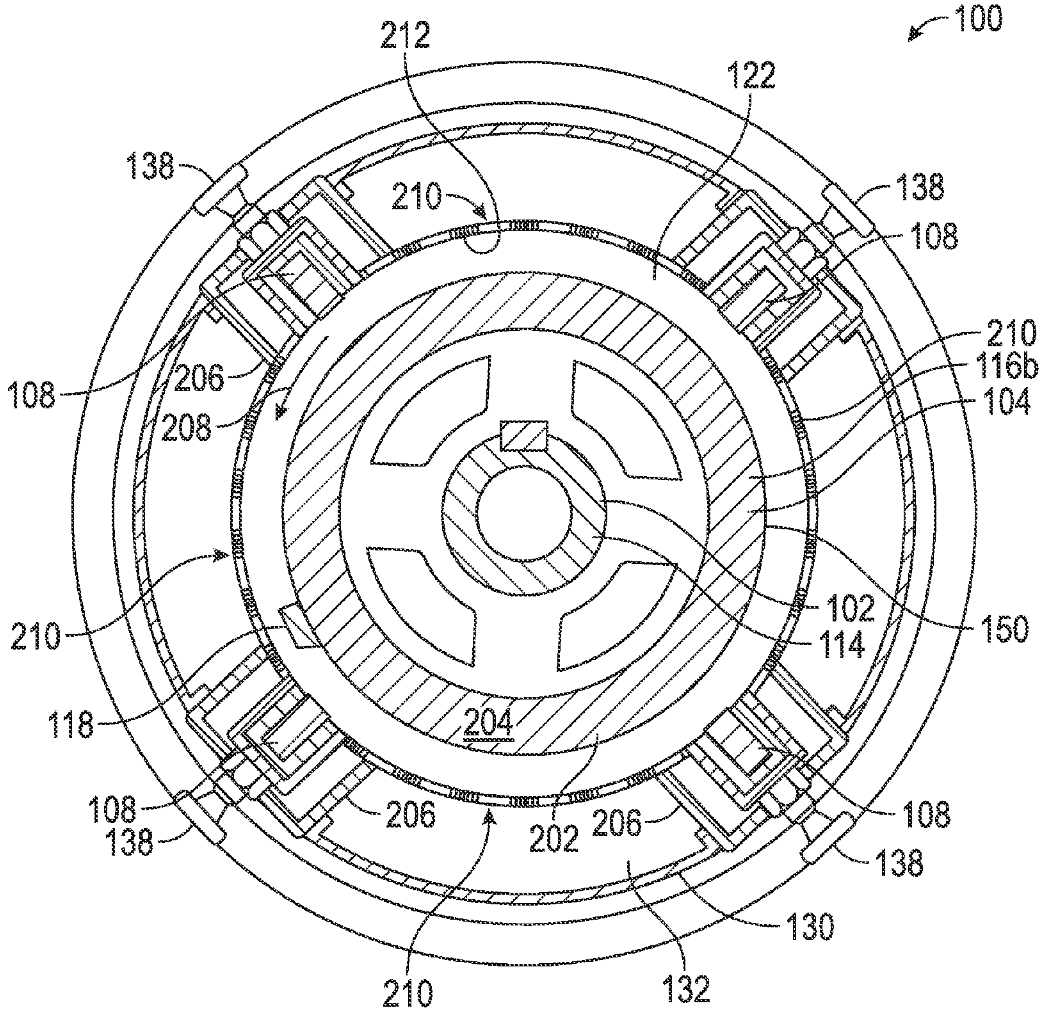

100
212
122
138
210
138
108
210
116b
104
108
206
208
102
150
114
210
118
204
108
138
206
202
206
108
138
130
132
210

FIG. 2

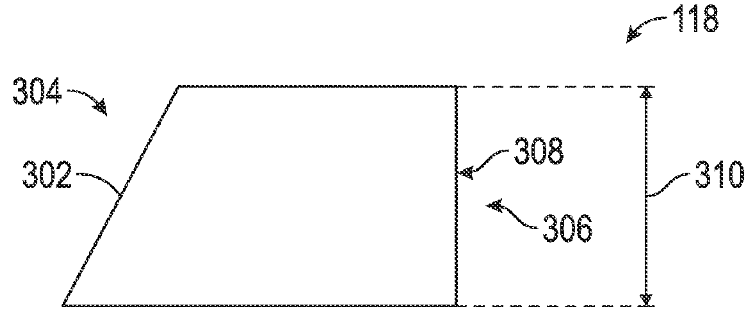

118
304
302
308
306
310

FIG. 3

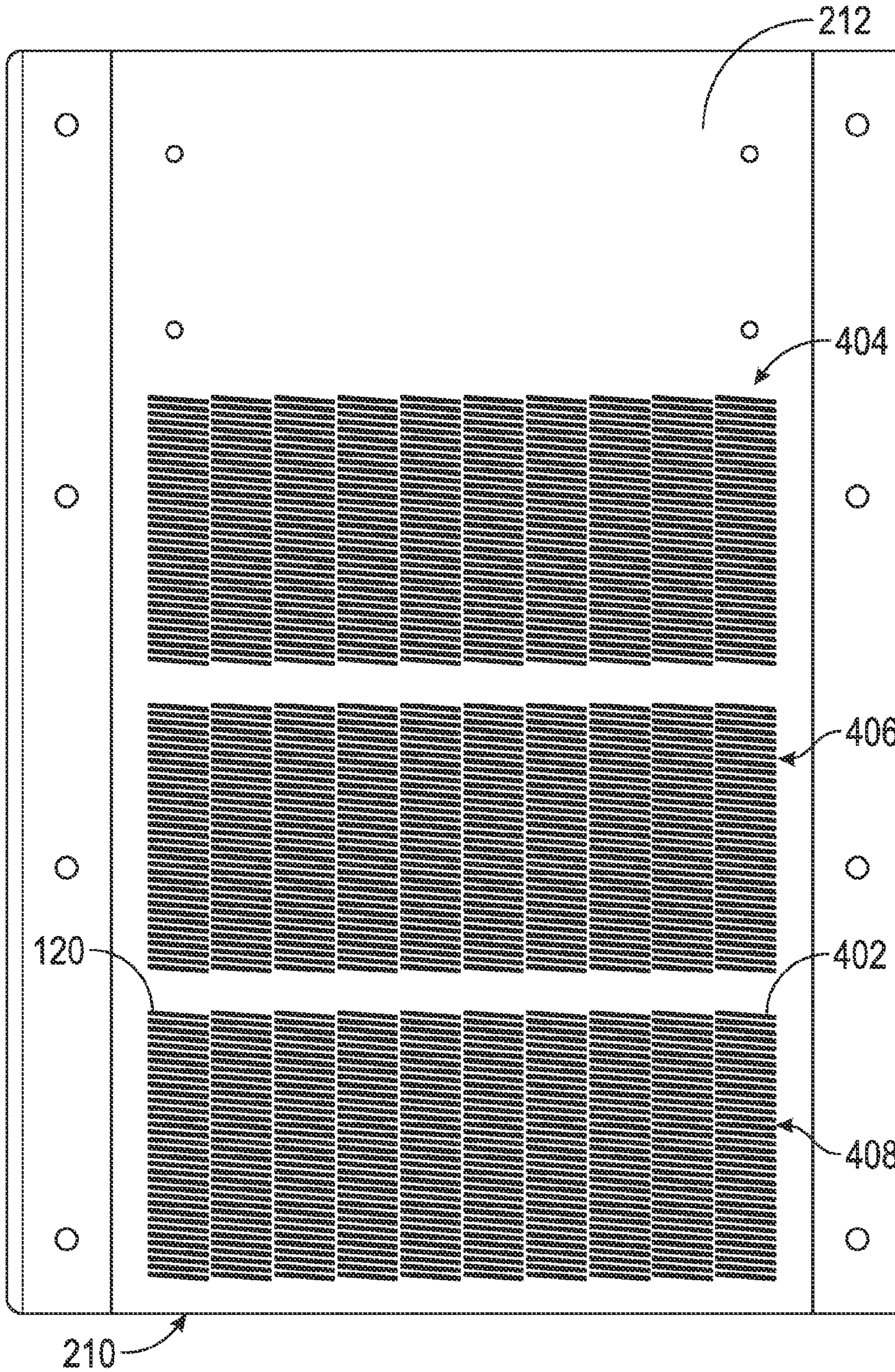


FIG. 4

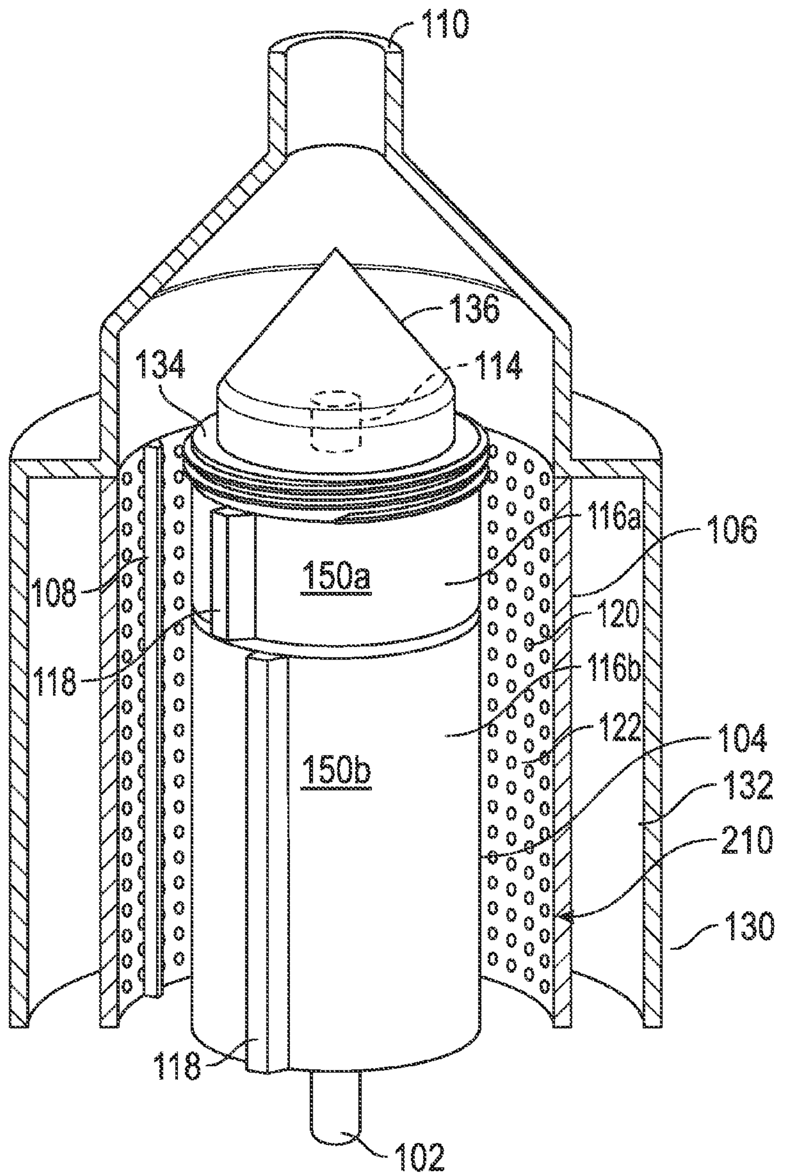

110
136
134
114
116a
106
150a
108
120
118
116b
122
104
150b
132
210
130
118
102

FIG. 5

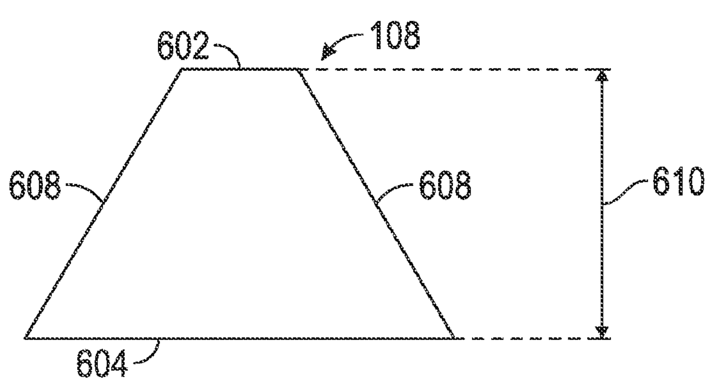
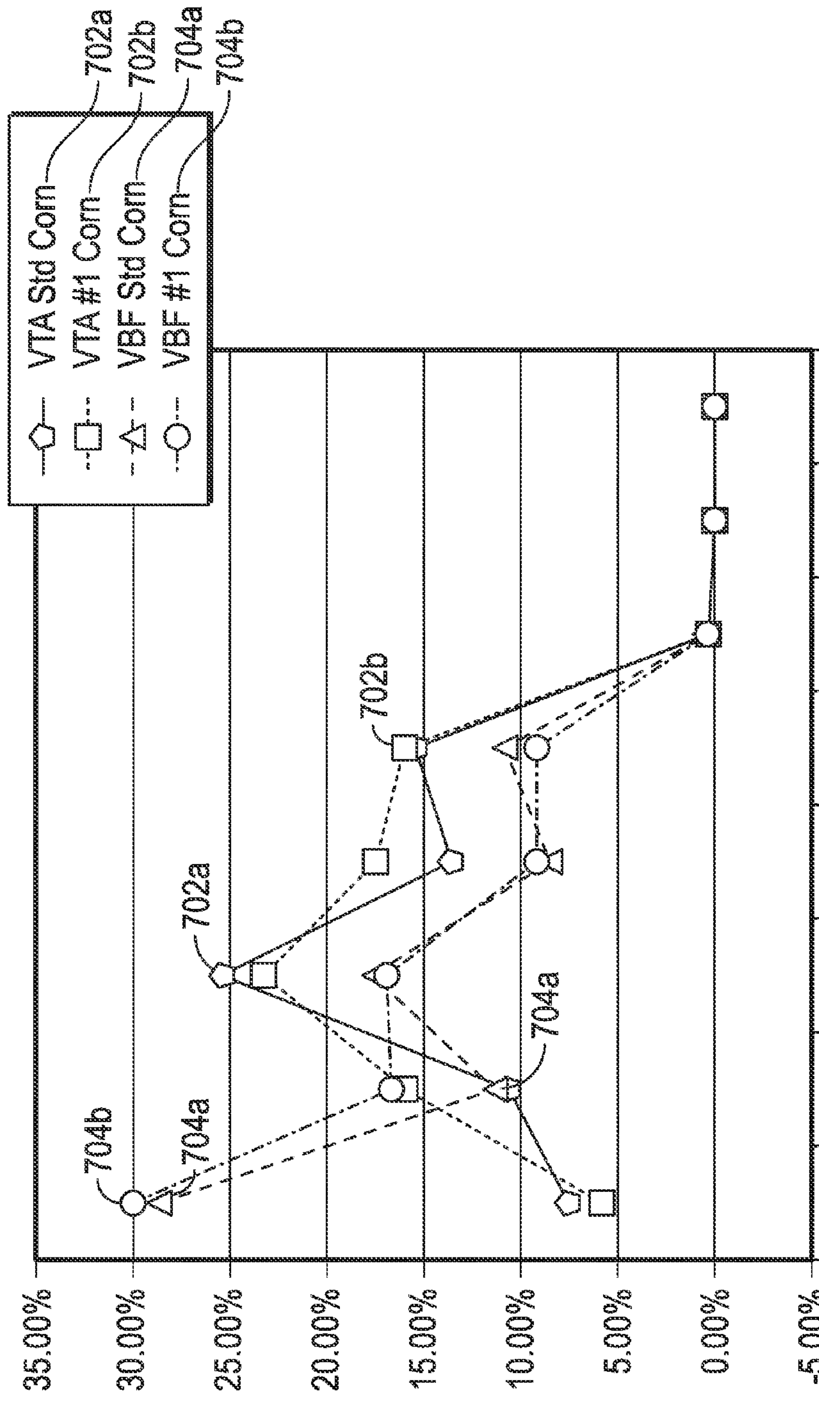

602
108
608
608
610
604

FIG. 6



	3.5	4	5	6	18	40	50	-50
702a VTA Std Corn	7.49%	10.63%	25.28%	13.49%	15.35%	0.20%	0.00%	0.00%
702b VTA #1 Corn	5.72%	15.89%	23.13%	17.44%	15.92%	0.17%	0.00%	0.00%
704a VBF Std Corn	28.70%	11.28%	17.72%	8.42%	10.78%	0.45%	0.00%	0.00%
704b VBF #1 Corn	29.89%	16.58%	16.83%	9.16%	9.06%	0.32%	0.00%	0.00%

FIG. 7

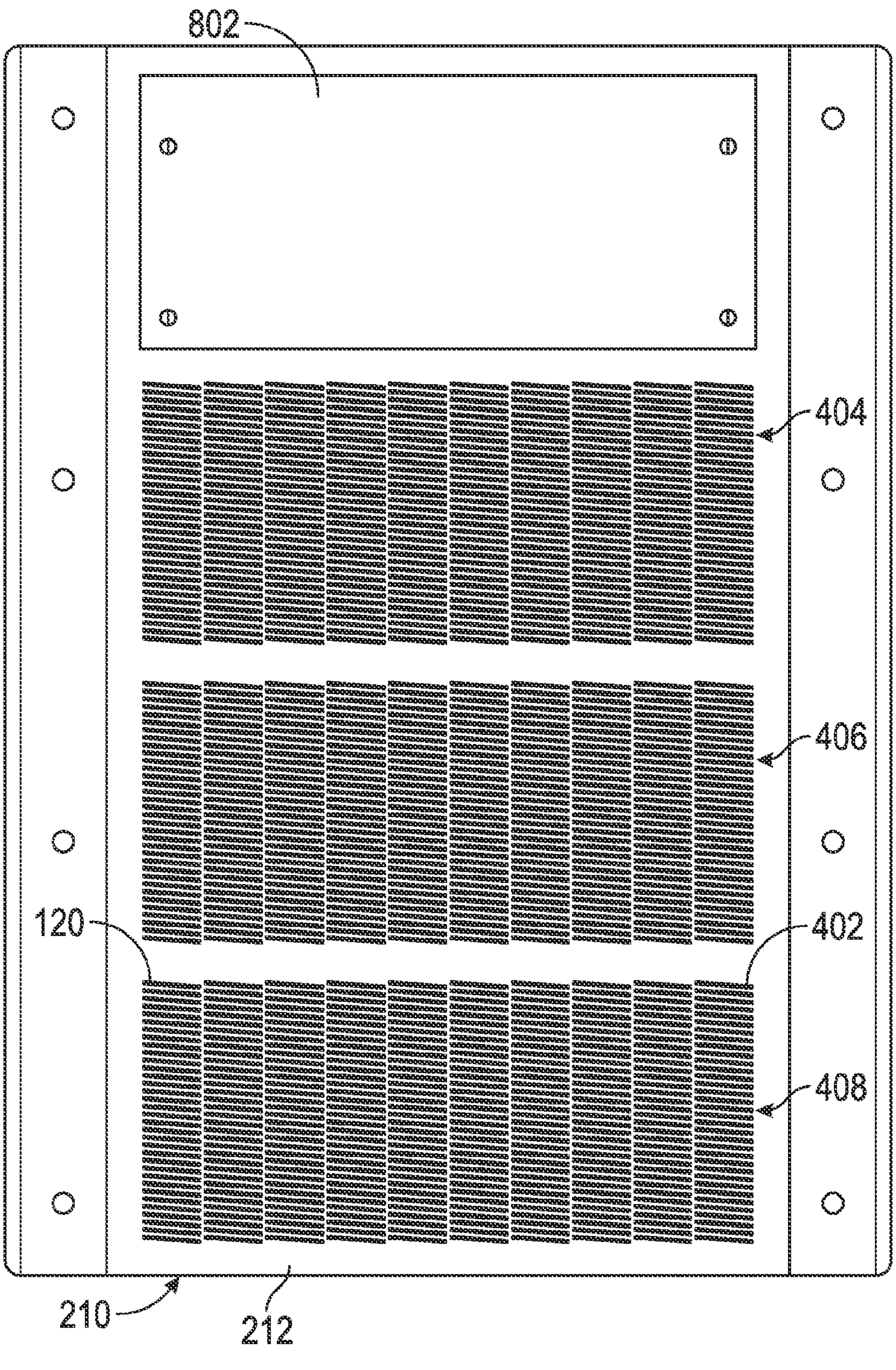


FIG. 8

VERTICAL TOP-FED GRAIN MILL

CROSS-REFERENCE TO RELATED APPLICATIONS

None.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

BACKGROUND

1. Field

The present disclosure pertains to a vertical top-fed grain mill (degermer). More particularly, the present disclosure relates to a grain milling machine which causes intermittent compression of grains while reducing potential overmilling.

2. Description of the Related Art

Milling machines are well known wherein grains, such as corn kernels, are debranned and the germ freed or exposed by application of impact force. Grains are supplied from a feeding inlet to a milling chamber having a milling roll, which serves as an impeller and which typically has an abrasive surface. The grains are then circulated by the milling roll, induced to move due to contact with the milling roll's abrasive surface, and are milled until exiting. The milling roll may include one or more agitating projections or stirring bars mounted on the milling roll within the milling chamber and/or may be elliptical to circulate the grains within the mill. During circulation, the grains rub one another, causing the bran layer to separate from the endosperm and germ. If the distance between the exterior of the milling roll and the milling chamber varies, such as by use of an elliptical milling roll or by use of a polygonal screen defining the exterior of the milling chamber, the grains within the milling chamber are additionally intermittently compressed, increasing the friction between the grains and increasing the internal stresses within the grains, thereby speeding bran removal and grain fracturing, respectively. Typically, a screen defines the extent of the milling chamber. The screen includes perforations to permit grain fragments, generally referred to as brokens, which may be germ, endosperm, bran or a combination thereof, of less than a maximum size, to exit the milling chamber. The force applied to the grains and the associated speed of processing may also be affected by selection of the size, density and direction of the perforations. Additionally, breaks or breaker bars may be installed about the screen that produce further localized areas of compression, which result in further fracturing of the kernels, or propagation of existing fractures within the kernels. Sufficient milling for exposing germ or for reduction of the grain broken size may be controlled by requiring a minimum force be applied to a discharge gate by or through the adjacent grains. Removal of sufficiently milled kernel brokens prior to reaching the top of the milling chamber may be permitted by sufficiently sized perforations in the screen. Those brokens passing through the screen are known as throughs. The grains and brokens passing through the mill to the output are known as overtails.

Various milling systems are known in the art for milling of grains. Some mills are horizontally aligned, wherein grains are input at one end of a horizontal-oriented mill, travel horizontally during milling and then exit. The Beall-type degermer is one such well-known horizontally-oriented mill. In a Beall-type degermer, corn is fed into and through the annulus at one end and between a rotating, conical rotor and

a stationary concentric screen made of perforated metal. Both rotor and screen are textured with large nodes, which impede motion of the kernels as they are impelled by the rotor.

Other mills are vertically-aligned, wherein grains are input at the top or the bottom of a vertically-oriented mill, travel downward or upward, respectively, during milling and then exit One such machine is the Satake Maize Degermer VBF. During rotation of the milling rotor in a vertical degermer, the corn is circulated horizontally by the milling rotor and is retained by the surrounding screen while moving in the vertical plan.

In both type of mills, as bran layers may remain with the pieces of endosperm after processing, further refinement may be necessary to reduce the fiber content of the endosperm product.

Problematically, grains that are sufficiently fractured early in the milling process continue to be milled with insufficiently fractured grains, often resulting in excessive milling and thereby degradation of products. It is generally desirable to minimize the production of fine particles, known as "fines" as these fines are difficult to separate in order to recover as a marketable product. One resolution has been the positioning of breaker bars at the section of the screen adjacent the discharge to accelerate fracturing of the kernels immediately prior to discharge. The breaker bars may substantially affect the output and milling time, as well as the power applied by the milling roll to the grains.

In horizontal mills and vertical bottom-fed mills, a substantial amount of energy is required for milling, which includes the energy needed to introduce grains to the machine and to drive already-present grains toward discharge. Vertical top-fed mills may avoid this issue by introducing grains at the top, but must then address the problem of increased milling resulting from the weight of the newly introduced grains atop those grains already being processed in connection with the abrasive roll.

Frequent screen replacement is typical in these mills, particularly as the screen surrounding the milling chamber wears, and often wears unevenly, particularly adjacent the point of introduction of the grains. The constant abrasion of the grains wears the periphery of the perforations of the screen. Such wear requires frequent screen replacement even though the remaining portions of the screen remain usable.

Thus, there is a need in the art for vertical grain mill which sufficiently mills grain at high rates of processing while addressing shortcomings of the prior art.

SUMMARY

The present disclosure therefore meets the above needs and overcomes one or more deficiencies in the prior art by providing a vertical grain mill which sufficiently mills grain at high rates of processing while addressing shortcomings of the prior art. In a first embodiment, the top-fed vertical grain mill includes a main shaft, a roll assembly, a bran removal cylinder, a resistor bar, a grain inlet and an overtails outlet. The main shaft is vertical, rotatable and has an upper portion. The roll assembly includes a plurality of rolls concentrically, removably affixed to the upper portion of the main shaft. Each of the rolls has a smooth, metal vertical outer periphery, a horizontal round cylindrical body of common diameter, a top surface and a bottom surface. On the outer periphery of each roll is a vertically-aligned stirring bar. The bran removal cylinder is vertically aligned and concentrically positioned distant the outer periphery of the plurality of rolls and has a plurality of perforations therethrough below the bottom surface of the top-most of the plurality of rolls. The resistor bar

is substantially vertical and positioned on an interior of the bran removal cylinder. The grain inlet, above the roll assembly, permits the provision of grain to the milling chamber between the roll assembly and the bran removal cylinder. The overtails outlet, below the roll assembly, permits the provision of overtails from the milling chamber.

In a second embodiment, the top-fed vertical grain mill includes a main shaft, a roll assembly, a bran removal cylinder, a resistor bar, an grain inlet and an overtails outlet. The main shaft is vertical, rotatable and has an upper portion. The roll assembly is removably concentrically affixed to the upper portion of the main shaft and includes a plurality of metal rolls removably concentrically affixed to the upper portion of the main shaft. Each of the plurality of rolls having a smooth, metal vertical outer periphery, a horizontal round cylindrical body of common diameter, a top surface and a bottom surface. On the outer periphery of each of the plurality of metal rolls, a vertically-aligned stirring bar is provided. The bran removal cylinder, which is internally round and vertical concentrically positioned distant the roll assembly, has a plurality of perforations therethrough. The resistor bar is substantially vertical and positioned on an interior of the bran removal cylinder. The grain inlet, above the roll assembly, permits the provision of grain to the milling chamber between the roll assembly and the bran removal cylinder. The overtails outlet, below the roll assembly, permits the provision of overtails from the milling chamber.

The present disclosure provides a mill which provides for efficient removal of bran from a grain, such as corn, while simultaneously breaking the endosperm into fractions, also know as grits, maximizing "large grit" while minimizing "small grit." The present disclosure further provides a mill which aids in separation of germ from endosperm fractions so as to minimize fat or oil contamination of the grits.

Additional aspects, advantages, and embodiments of the disclosure will become apparent to those skilled in the art from the following description of the various embodiments and related drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the described features, advantages, and objects of the disclosure, as well as others which will become apparent are attained and can be understood in detail; more particular description of the disclosure briefly summarized above may be had by referring to the embodiments thereof that are illustrated in the drawings, which drawings form a part of this specification. It is to be noted, however, that the appended drawings illustrate only typical preferred embodiments of the disclosure and are therefore not to be considered limiting of its scope as the disclosure may admit to other equally effective embodiments.

In the drawings:

FIG. **1** is an illustration of one embodiment of the present disclosure along its center illustrating the various components.

FIG. **2** is an illustration of the embodiment of FIG. **1** taken along plane A-A.

FIG. **3** is an illustration of a side view of an embodiment of a stirring bar of the present disclosure.

FIG. **4** is an illustration of a screen segment of the bran removal cylinder of the present disclosure.

FIG. **5** is an illustration of an exploded view of various components of the present disclosure for a second embodiment of the disclosure.

FIG. **6** is an illustration of a side view of an embodiment of resistor bar of the present disclosure.

FIG. **7** is an illustration of an actual test result comparing the output of an embodiment of a disclosure to an existing bottom-fed mill for two types of corn.

FIG. **8** is an illustration of a screen segment of the bran removal cylinder with a wear plate.

DESCRIPTION

Referring to FIG. **1**, the top-fed vertical grain mill **100** according to the present disclosure is illustrated. The top-fed vertical grain mill **100** includes a main shaft **102**, a roll assembly **104**, a bran removal cylinder **106**, a resistor bar **108**, a grain inlet **110** and an overtails outlet **112**. The main shaft **102** is vertical, rotatable and has an upper portion **114**. The roll assembly **104** includes a plurality of rolls **116*a*-116*g*** concentrically, removably affixed to the upper portion **114** of the main shaft **102**. Referring to FIGS. **1**, **2**, and **5**, each of the rolls **116*a*-116*g*** has a smooth, metal substantially-vertical outer periphery **150*a*-150*g***, a horizontal round cylindrical body **202** of common maximum diameter, a top surface **204** and a bottom surface **152**. On the outer periphery **150** of each roll **116** is a vertically-aligned stirring bar **118**. The bran removal cylinder **106** is vertically aligned and concentrically positioned distant the outer periphery **150*a*-150*g*** of the plurality of rolls **116*a*-166*g*** and has a plurality of perforations **120** therethrough, in one embodiment limited to a position below the bottom surface **152** of the top-most of the plurality of rolls **116*a*** and the bottom **154** of the bran removal cylinder **106**. The resistor bar **108** is substantially vertical and positioned on an interior of the bran removal cylinder **106**. The grain inlet **110**, above the roll assembly **104**, permits the provision of grain to the milling chamber **122** between the roll assembly **104** and the bran removal cylinder **106**. The overtails outlet **112**, below the roll assembly **104**, permits the provision of overtails from the milling chamber **122**.

Referring to FIG. **1**, the top-fed vertical grain mill **100** may also include a frame **124**, wherein the main shaft **102**, and therefore also the roll assembly **104**, is supported. A motor **126** may be affixed to the frame **124** and coupled to the main shaft **102** to cause rotation of the main shaft **102**, and therefore of the roll assembly **104**, during operation of the top-fed vertical grain mill **100**. The frame **124** may include a horizontal surface **128** below the roll assembly **104** to define the bottom of the milling chamber **122**. The overtails outlet **112**, positioned below the horizontal surface **128**, may be affixed to the frame **124**, which may include an orifice through the horizontal surface **128** of the frame **124** for communication between the milling chamber **122** and the overtails outlet **112**. Referring to FIG. **2**, the bran removal cylinder **106** may be attached to the frame **124** by attachment to pillars **206** of the frame **124**. Referring to FIGS. **1** and **2**, an outer wall **130** may be attached to the frame **124** and may be placed external to the bran removal cylinder **106**, defining an annular bran removing chamber **132**. This annual bran removing chamber **132** may communicate with a throughs outlet **156** for removal of the throughs from the top-fed vertical grain mill **100**. Referring again to FIG. **1**, the grain inlet **110** is connected to the frame **124** and provides the inlet for gravity-supplied grain to enter the top-fed vertical grain mill **100**. The frame **124** may also support a guide body **136**. When falling grain enters the top-fed vertical grain mill **100** through the grain inlet **110**, it first contacts the guide body **136**, then is guided to a spiral rotor, or conveyor, **134** mounted to the main shaft **102**. The spiral rotor **134** then provides grain from the grain inlet **110** to the milling chamber **122** so as to be generally equivalently dispersed in the milling chamber **122**.

Referring to FIGS. **1** and **2**, each roll **116** of the roll assembly **104** provides a smooth, metal substantially-vertical outer periphery **150***a*-**150***g* rather than an abrasive surface, such as an emery stone typically used as an abrasive grinding stone. While some surface imperfections of the outer periphery **150***a*-**150***g* may result in some friction between the grains and the roll **116***a*-**116***g*, the coefficient of friction is negligible and therefore does not provide sufficient friction to aggressively wear the bran from the exterior of the grain. Any change in the application of force applied to the grains by the roll **116***a*-**116***g* itself is further reduced by using rolls **116***a*-**116***g* which are round, rather than elliptical. Each of these rolls **116***a*-**116***g* is then attached to the main shaft **102**, and each **116***a*-**116***g* may be separated from an adjacent vertically-adjacent roll **116***a*-**116***g* by a spacer inserted between the rolls **116***a*-**116***g* or by a gapping system intended to provide positive airflow such as from main shaft **102**, if a hollow main shaft is used, to the milling chamber **122**. Once each roll **116***a*-**116***g* is affixed to the main shaft **102**, an integral unit—the roll assembly **104**—is formed. The outer periphery **150***a*-**150***g* of the rolls **116***a*-**116***g* in the roll assembly **104** defines the inner diameter of the milling chamber **122**. As can be appreciated, in the roll assembly **104**, the topmost roll **116***a* might not have an outer periphery **150***a* which is entirely vertical, but rather may have an outer periphery **150***a* which is only substantially vertical, such that the top surface of the topmost roll **116***a* may be smaller in diameter than the bottom surface **152** of the topmost roll **116***a*, producing a canted periphery **150***a* which aids in the downward flow of the grains introduced to the top-fed vertical grain mill **100**. Preferably, the outer periphery **150***a*-**150***g* of each of the rolls **116***a*-**116***g* is formed of steel, which is sufficiently smooth as to prevent undesirably grain rubbing and which is sufficiently durable to resist the wearing forces from the grain passing through the top-fed vertical grain mill **100**.

At least one vertically-aligned stirring bar **118** is affixed, such as by one or more bolts, or other fastening systems, to each roll **116***a*-**116***g* of the roll assembly **104** on its outer periphery **150***a*-**150***g*, preferably having a height equal to that of the roll **116***a*-**116***g* such that the stirring bar **118** extends from the top surface **204** to the bottom surface of the roll assembly **104**. More than one stirring bar **118** may be utilized, provided sufficient spacing about the periphery of the roll **116***a*-**116***g* is provided so that grains may be contacted by and impelled by the stirring bar **118**. The thickness of the stirring bar **118** is selected to ensure the quantity, size, and type of grain in the mill, such as corn, barley, or wheat, is induced to move about the milling chamber **122** during operation. Barley, for example, provides a grain notably smaller than corn, and therefore would require a milling chamber **122** and stirring bar **118** sized differently than a milling chamber **122** and stirring bar **118** for use in connection with corn. The various rolls **116***a*-**116***g* preferably, but not necessarily, are positioned on the main shaft **102** so that the associated stirring bars **118** are not aligned vertically. Each stirring bar **118** is made of a durable material, such as steel, sufficient to endure the force of the grains on its surface during rotation. Each stirring bar **118** provides a profile extending sufficiently from the outer periphery **150***a*-**150***g* of each roll **116***a*-**116***g* to induce movement of the grains adjacent the roll **116***a*-**116***g*. Referring to FIGS. **2** and **3**, this profile may be a trapezoidal prism. Alternatively, the profile of the stirring bar **118** may be another shape sufficient to induce movement, such as half an elliptical cylinder—which may be used to avoid the generation of an edge which may cause localized stresses in the grains from the stirring bar **118**. The stirring bar **118** has a height substantially equal to the height of the roll **116**. Referring to FIGS. **2** and **3**, each stirring bar **118** may be mounted on a roll **116***a*-**116***g* such that its vertically extending chamfer **302** is found on the forward side **304** in the rotational direction **208** of the roll assembly **104** and that its vertically extending edge portion (rising portion) **306** is found on the rear side **308**. By mounting stirring bar **118** such that the chamfer **302** is on the forward side **304** in the rotational direction **208** of the roll assembly **104**, a comparatively gentle stirring action is obtainable.

The bran removal cylinder **106**, which defines the outer boundary of the milling chamber **122**, is internally-round, vertical cylinder concentrically positioned distant the outer periphery **150***a*-**150***g* of each of the plurality of rolls **116***a*-**116***g*. The bran removal cylinder **106** may be formed of two or more segments **210** which may be joined together to provide the uprightly-formed round cylinder **106**, and is formed of a durable material, such as steel, sufficient to endure the force of the grains on its surface **212** during rotation.

The bran removal cylinder **106** has a plurality of perforations **120** therethrough. In the first embodiment, these perforations **120** may be limited to the area below the bottom surface **152** of a top-most roll **116***a* of the plurality of rolls **116***a*-**116***g*. The size, alignment, direction, and shape of the perforations **120** may be selected depending on a number of factors, including grain type, water content, desired bran size, and rate of milling. Perforations **120** may be round or elliptical and, in the case of elliptical perforations may be angled relative to the screen surface **212**. Thus, the bran removal cylinder **106** has a porous wall portion and is uprightly formed. Perforations **120** therefore are laterally present about the entire inner circumference of the bran removal cylinder **106**. As depicted in FIG. **4**, in connection with a four piece bran removal cylinder **106**, such as depicted in FIG. **2**, the perforations **120** may be slotted perforations **402**, essentially elliptical in shape and angled upwards from the horizontal plan when viewed from direction of rotation **208**. Other sizes (width, height, orientation, and shape) and arrangements of perforations **120** may be used, subject to the restriction that none are operable above the bottom surface **152** of the top roll **116***a* of the plurality of rolls **116***a*-**116***g*. Where slotted perforations **402** are used, each may be 25 millimeters in length with a 0.9 millimeter height, on 3.5 millimeter centers, at an angle of not more than 7.5 degrees and not less than 2.7 degrees, and preferably about 4.6 degrees. These perforations **402** may be grouped to address the second and third rolls **116***b*, **116***c* in a first perforation group **404**, to address the fourth and fifth rolls **116***d*, **116***e* in a second perforation group **406**, and the sixth and seventh rolls **116***f*, **116***g* in a third perforation group **408**, if seven rolls are used. As depicted in FIGS. **1** and **4**, in one embodiment, the perforations **120** are not found above the bottom surface **152** of the top roll **116***a* of the plurality of rolls **116***a*-**116***g* should the milling obtained by a top-fed vertical grain mill **100** using a smooth roll with a stirring bar **118**, a round screen **106**, and a resistor bar **118** cause the bran removal cylinder **106** to wear out rapidly at the portion adjacent the top roll **116***a*. Alternatively, the perforations **120**, **402** may be found throughout the bran removal cylinder **106**, including above the bottom surface **152** of the top roll **116***a* of the plurality of rolls **116***a*-**116***g*

Additionally, referring to FIG. **8**, a wear plate **802** may be affixed to the bran removal cylinder **106** in the area opposite the first roll **116***a* when the bran removal cylinder **106** is installed. The wear plate **802** is provided without any perforations and is sized to fit to and within the bran removal cylinder **106** without interfering with operation of the top-fed vertical grain mill **100**, particularly with regard to the stirring bar **118** associated with the first roll **116***a* and the resistor bar

108. Thus, an internally-round, vertical wear plate **802** is affixed internally to the internally-round, vertical bran removal cylinder **106** above the bottom surface **152** of the top-most of the plurality of rolls **116***a*. The internally-round, vertical bran removal cylinder **106** may therefore include the limitation of the perforations **120** being only below the bottom surface **152** of a top-most **150***a* of the plurality of metal rolls **150***a*-**150***g* or may include perforations **120** above the bottom surface **152** of a top-most **150***a* of the plurality of metal rolls **150***a*-**150***g* which are then masked from contact with product by the wear plate **802**.

At least one substantially vertical resistor bar **108** is positioned on the interior of the bran removal cylinder **106**, preferably spanning the entire height of the bran removal cylinder **106**. The resistor bar **108** may be affixed to a portion of the frame **124** surrounding the bran removal cylinder **106**, as illustrated in FIG. **1**, or directly to the bran removal cylinder **106**, as illustrated in FIG. **5**. Each resistor bar **108** may be inserted or extracted using a plurality of knob bolts **138**. Each resistor bar **108** is made of a durable material, such as steel, sufficient to endure the force of the grains on its surface during contact. Each resistor bar **108** provides a profile extending sufficiently from the screen surface **212** of the bran removal cylinder **106** to retard movement of the grains adjacent the bran removal cylinder **106** in the milling chamber **122**. This may be accomplished by a rectangular profile, such as illustrated in FIG. **2**, or a trapezoidal prism profile which may include a parallel top **602** and bottom **604** and chamfers front **606** and rear **608** of equal cant, such as depicted in FIG. **6**, or another shape sufficient to retard movement, such as half an elliptical cylinder. The sum of the height **310** of a stirring bar **118** and the height **610** of a resistor bar **108** is greater than the distance between the outer periphery **150***a*-**150***g* of the plurality of rolls **116***a*-**116***g* and screen surface **212** of the bran removal cylinder **106**, so that a stirring bar **118** may rotate past a resistor bar **108** without interference other than that caused the intermediate grains.

The overtails outlet **112** is disposed at the lower end of the milling chamber **122** so as to discharge the grain milled by the top-fed vertical grain mill **100**. The overtails outlet **112** includes a discharge port **140** that is formed by opening a part of the bran removal cylinder **106**, an outlet opening **142** that is connected to the discharge port **140**, a weight lever **144** that is fixed to a shaft **146** transversely suspended on the outlet opening **142**, a resisting plate **148** that is pivoted to one end of the weight lever **144** and faces the discharge port **140** so as to block it, and a weight **145** that is movably attached to the other end of the weight lever **144**.

In operation, the motor **126** causes the main shaft **102** to rotate, during which grain, particularly corn, is introduced to the top-fed vertical grain mill **100** via the grain inlet **110**. Various systems are known in the art for distribution of downwardly falling grain from a source to the milling chamber **122**. In one embodiment, prior to introduction to the top-fed vertical grain mill **100**, the grain may be stored any various systems known in the art, including a raw material tank, which may be associated with a valve to control flow of grain into the top-fed vertical grain mill **100**. The downwardly flowing grain introduced to top-fed vertical grain mill **100** is somewhat equally dispersed circumferentially by the guide body **136**, which provides a cone for distribution of grain, and which them conveys the grain to the spiral rotor **134**. The grain is then introduced to the milling chamber **122** by the spiral rotor **134**.

The grain enters the milling chamber **122**, which may including impinging on the outer periphery **150***a* of the first roll **116***a* plurality of rolls **116**. Grain then at least partially fills the milling chamber **122**, potentially until the entire milling chamber **122** is full and grain is standing in the grain inlet **110**. It is therefore desirable to provide a canted outer periphery **150***a* of the first roll **116***a* of the plurality of rolls **116***a*-**116***g* to aid in efficient introduction of grain to the milling chamber **122** and to avoid undesirable overwear of the portion of the bran removal cylinder **116** adjacent thereto. During this filling and afterward during operation, the rolls **116***a*-**116***g* are being rotated due to their connection to the main shaft **102**. Due to the rotation of the rolls **116** in the roll assembly **104**, the stirring bars **118** are rotating about the main shaft **102** in the milling chamber **122**, impelling grains circumferentially about the roll assembly **104**.

Because the bran removal cylinder **116** is round, rather than a polygonal screen, the bran removal cylinder causes no localized areas of varying stress and force within the grains. Polygonal screens, because of the varying distance between the screen and roll assembly, generate areas of low force and inter-grain friction—at the point of greatest distance between the screen and roll assembly, and areas of high force and inter-grain friction—at the point of least distance between the screen and roll assembly. Instead, because the distance between the bran removal cylinder **106**, and particularly the bran removal chamber outer wall **132**, is constant, the width of the milling chamber **122** is constant, with the exception of localized areas about the resistor bars **108** and the stirring bars **118**, the force applied among the grains, which initially will cause inter-grain friction and separation of bran by rubbing and then will cause propagation of fractures through the remaining germ/endosperm/bran of the grains, has a substantially smaller variance. The smooth, durable outer periphery **150***a*-**150***g* of each of the plurality of rolls **116***a*-**116***g* reduces the rotational force and rubbing introduced by the rolls **116***a*-**116***g* to a negligible value.

As the rolls **116***a*-**116***g* are being rotated and the stirring bars **118** impel grains circumferentially about the roll assembly **104** within the milling chamber **122**, the movement of the grains, broken grains and debranned grains, is retarded by the resistor bar **108**, which increases the inter-grain force and provides a localized area of higher force and stress in the milling chamber **122** which increases the separation of bran by rubbing and the propagation of fractures through the remaining germ/endosperm/bran of the grains, i.e., grain milling.

Coupled with the lack of rubbing from the smooth rolls **116**, the increases in inter-grain rubbing from the stirring bars **118** and the resistor bar **108**, the construction of the perforations **120** in the bran removal cylinder **106** increases the rate of milling while avoiding overmilling. The perforations **120** permit the throughs, including bran and any overmilled "fines", to exit the milling chamber **122**, while retaining the remaining grain components. Additionally, the perforations **120** in the bran removal cylinder **106** present surfaces which cause impact forces to be applied to passing grains, causing those grains to fracture into desirable components.

The milled grain components not exiting the milling chamber **122** but rather exiting via the overtails outlet **112** are, as a result of a top-fed mill with beneficially sufficiently milled without issues of overmilling or undermilling.

Beneficially, the combination of the smooth roll **116***a*-**116***g* with a stirring bar **118**, a round screen **106** where the perforations are limited to the area below the bottom surface **152** of a top-most roll **116***a* of the plurality of rolls **116***a*-**116***g*, and a resistor bar **118** result in a more desirable output. The output of the top-fed vertical grain mill **100** for two corn types **702***a*, **704***a*, is better in size and distribution for mesh sizes than the output from a conventional mill for the same corn two types **702***b*, **704***b* as illustrated in FIG. **7**.

Thus, the top-fed vertical grain mill **100** provides for efficient removal of bran from a grain, such as corn, while simultaneously breaking the endosperm into fractions, also known as grits, maximizing "large grit" while minimizing "small grit." The top-fed vertical grain mill **100** aids in separation of germ from endosperm fractions so as to minimize fat or oil contamination of the grits. Referring to FIG. **7**, the top-fed vertical grain mill **100** provides a desirable granulation distribution of corn grits. The top-fed vertical grain mill **100** produces higher percentages of larger grit (+4 Mesh, +5 Mesh, +6 Mesh) while simultaneously reducing the percentage of large unbroken kernels (grains) (+3.5 Mesh). This improved distribution impacts the requirements for further processing or recycling of the +3.5 Mesh Fraction, particularly the need for additionally machine content, horsepower and the like.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof. It will be evident to those skilled in the art that various modifications and changes can be made thereto without departing from the broader spirit or scope of the disclosure. Accordingly, the specification is to be regarded in an illustrative rather than a restrictive sense. It is therefore, contemplated that various alternative embodiments and modifications may be made to the disclosed embodiments without departing from the spirit and scope of the disclosure defined by the appended claims and equivalents thereof.

I claim:

1. A top-fed vertical grain mill, comprising:

a vertical, rotatable main shaft having an upper portion;

a roll assembly,

the roll assembly having a plurality of rolls removably concentrically affixed to the upper portion of the main shaft,

each of the plurality of rolls having a smooth, metal substantially vertical outer periphery, a horizontal round cylindrical body of common diameter, a top surface and a bottom surface,

a vertically-aligned stirring bar provided on the outer periphery of each of the plurality of rolls;

an internally-round, vertical bran removal cylinder concentrically positioned distant the outer periphery of each of the plurality of rolls, the bran removal cylinder having a plurality of perforations therethrough below the bottom surface of a top-most of the plurality of rolls;

a resistor bar, the resistor bar substantially vertical and positioned on an interior of the bran removal cylinder;

a grain inlet to a milling chamber between the roll assembly and the bran removal cylinder, the grain inlet above the roll assembly; and

a overtails outlet from the milling chamber, the overtails outlet below the roll assembly.

2. The mill of claim **1**, wherein the smooth, metal vertical outer periphery of each of the plurality of rolls is formed of steel.

3. The mill of claim **2**, wherein the stirring bar includes a chamfer formed on a forward side with respect to a direction of travel of the plurality of rolls.

4. The mill of claim **3**, wherein each of the plurality of perforations is one of round in shape and slotted in shape.

5. The mill of claim **4**, wherein each of the plurality of perforations is about 25 millimeters in length, about 0.9 millimeter height, on 3.5 millimeter centers, and at an angle of not more than 7.5 degrees and not less than 2.7 degrees.

6. The mill of claim **5**, further comprising an internally-round, vertical wear plate affixed internally to the internally-round, vertical bran removal cylinder corresponding to the area above the bottom surface of a top-most of the plurality of rolls.

7. The mill of claim **1**, further comprising an internally-round, vertical wear plate affixed internally to the internally-round, vertical bran removal cylinder corresponding to the area above the bottom surface of a top-most of the plurality of rolls.

8. The mill of claim **7**, wherein said internally-round vertical wear plate is without perforations therethrough.

9. A top-fed vertical grain mill, comprising:

a vertical, rotatable main shaft having an upper portion;

a roll assembly removably concentrically affixed to the upper portion of the main shaft,

the roll assembly having a plurality of metal rolls,

each of the plurality of rolls having a smooth, metal substantially-vertical outer periphery, a horizontal round cylindrical body of common diameter, a top surface and a bottom surface,

a vertically-aligned stirring bar provided on the outer periphery of each of the plurality of metal rolls;

an internally-round, vertical bran removal cylinder concentrically positioned distant the roll assembly, the bran removal cylinder having a plurality of perforations therethrough;

a resistor bar, the resistor bar substantially vertical and positioned on an interior of the bran removal cylinder;

a grain inlet to a milling chamber between the roll assembly and the bran removal cylinder, the grain inlet above the roll assembly; and

a overtails outlet from the milling chamber, the overtails outlet below the roll assembly.

10. The mill of claim **9**, wherein none of the plurality of perforations are positioned above the bottom surface of a top-most of the plurality of metal rolls.

11. The mill of claim **9**, wherein the smooth, metal vertical outer periphery of each of the plurality of rolls is formed of steel.

12. The mill of claim **11**, wherein the stirring bar includes a chamfer formed on a forward side with respect to a direction of travel of the plurality of rolls.

13. The mill of claim **12**, wherein each of the plurality of perforations is one of round in shape and slotted in shape.

14. The mill of claim **13**, wherein each of the plurality of perforations is about 25 millimeters in length, about 0.9 millimeter height, on 3.5 millimeter centers, and at an angle of not more than 7.5 degrees and not less than 2.7 degrees.

15. The mill of claim **14**, further comprising an internally-round, vertical wear plate affixed internally to the internally-round, vertical bran removal cylinder corresponding to the area above the bottom surface of a top-most of the plurality of rolls.

16. The mill of claim **11**, further comprising an internally-round, vertical wear plate affixed internally to the internally-round, vertical bran removal cylinder corresponding to the area above the bottom surface of a top-most of the plurality of rolls.

17. The mill of claim **16**, wherein said internally-round vertical wear plate is without perforations therethrough.

18. The mill of claim **17**, wherein said perforations through said bran removal cylinder are positioned below the bottom surface of a top-most of the plurality of rolls.

* * * * *